PROJECT

facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

High Efficiency Engines and Turbines

11/2002

NETL

PRIMARY PARTNER

Mississippi State University
Mississippi State, MS 39762

TOTAL ESTIMATED COST

$ 321,374

CUSTOMER SERVICE

800-553-7681

STRATEGIC CENTER FOR NATURAL GAS WEBSITE

www.netl.doe.gov/scng

REAL SURFACE EFFECTS ON TURBINE HEAT TRANSFER AND AERODYNAMIC PERFORMANCE

Description

Under the Advanced Gas Turbine Systems Research (AGTSR) program, the Air Force Institute of Technology and Mississippi State University are conducting a project to characterize the effects of service conditions on turbine vane and blade heat transfer and aerodynamic performance. Surface profiles are measured and catalogued for turbine parts that had experienced a range of service, which had produced surface erosion, corrosion, deposition and coating spallation. The next phase produces scaled models of measured surfaces from turbine parts for wind tunnel experiments in which heat transfer and aerodynamic data is obtained for those surfaces.

Over 100 turbine parts have been obtained from Allied-Signal, GE, Siemens-Westinghouse, and Solar Turbines. These components had experienced service in turbines under a wide range of conditions. Two and three-dimensional surface roughness measurements have been completed and the data have been catalogued into a data base.

Tests have been conducted to determine turbine design parameters associated with the measured surface roughness contours. Five scaled surface models corresponding to different turbine service conditions were constructed for wind tunnel tests that measured aerodynamic and heat transfer parameters (skin friction and heat transfer coefficient) needed for design of turbine airfoils. These tests showed that, depending on service environment for the represented part, skin friction augmentation ratios (referenced to smooth surfaces) varied from 1.44 to 2.68. Heat transfer augmentation ratios (referenced to smooth surfaces) varied from 1.16 to 1.45. Figures 1 and 2 give the variation in skin friction and heat transfer parameter (Stanton number) for the represented turbine surfaces compared to smooth surfaces. Other data show that existing heat transfer and skin friction correlations severely underpredict effects of roughness for small equivalent sand grain roughness. The project has proposed improved methods for predicting the effects of roughness.

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

Duration

36 months

Real Surface Effects on Turbine Heat Transfer and Aerodynamic Performance

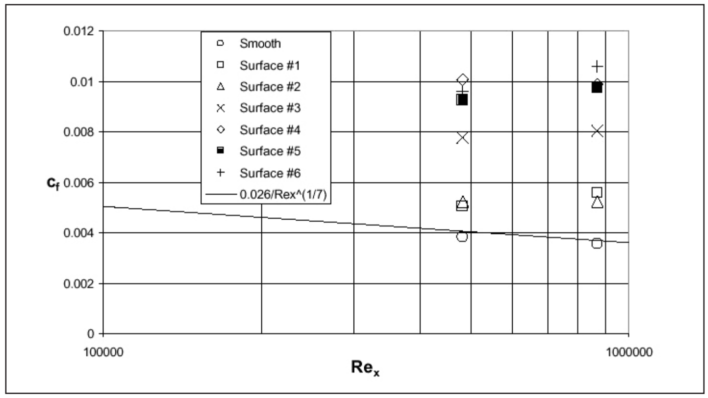

Figure 1. Skin friction vs. Reynolds number for smooth and rough panels

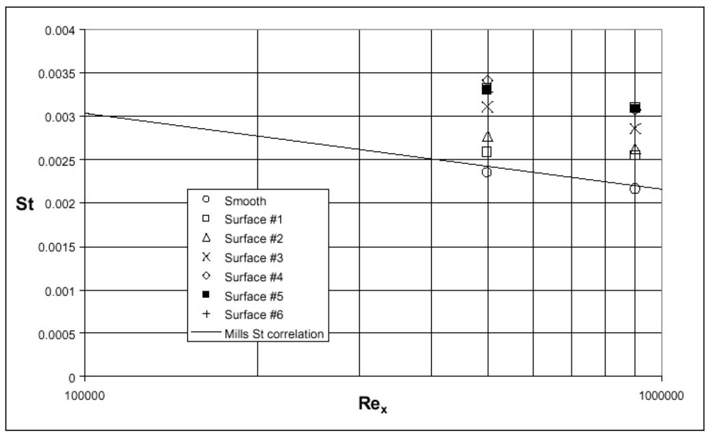

Figure 2. Staton number vs. Reynolds number for smooth and rough panels

Goals

Turbine vane and blade airfoil surface characteristics change with operation time due to erosion, corrosion, deposition, and spallation of coatings from the parts. These surface changes can degrade the airfoil aerodynamics and cooling from their initial finely tuned, as manufactured, levels. Past analyses of vanes and blades that had experienced service have shown that methods established by turbine manufacturers to characterize airfoil surface roughness for aerodynamic and heat transfer analyses are not universally appropriate. This project obtains data to better characterize surface degradations of real turbine parts that have experienced service

Benefits

Surface roughness characterization for turbines that have experienced a range of service conditions are being obtained. The data show that one set of heat transfer and skin friction parameters is not sufficient to represent all turbine service conditions and give representative values for these parameters as a function of service condition. The surface roughness measurement data base and data from the wind tunnel tests representing the observed roughness are being provided to turbine manufacturers to improve their tools for design and analyses of airfoils.

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